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PHOTOGRAPHY WITH HIGH POWERS BY LAMPLIGHT :

ILLUSTRATING STRUCTURE OF DIATOMS.

By JACOB D. COX, LL.D., F. R. M. S., Cincinnati, O.

In the investigations into the structure of the diatom-shell which for some years I have been making, it has been my habit to mark by the Maltwood finder, and enter in my note-book the more striking examples of broken valves which I met and which seemed to throw useful light upon mooted questions. How to make this evidence available was a somewhat troublesome problem; but it is one which recent improvements in dry gelatine-plates for photography seem to have solved very happily. Duties of other sorts prevented my using the day-light hours for work of this kind, and I was for some time deterred from attempting to photograph by lamp-light by the belief that it would not be found available for the high powers I desired to use. Amplifications of from one to two thousand diameters were what I wanted to have at command, and until quite lately it did not seem likely that this could be secured in photography by lamp.

During the preparation of some articles on diatom-structure which were published last spring in the *American Monthly Microscopical Journal*, I determined, with some hesitation, to test the usefulness of this method of illustration. Beginning in April, I have made between fifty and sixty negatives of what I have called a "Broken Shell Series," and of some two dozen of these I have made positive transparencies which I shall show you by aid of the projection lantern.

The apparatus I use is very simple. It consists of Walmsley's Photomicrograph camera with cone of *papier maché* attached, and a common coal-oil lamp with broad, flat wick. The lamp I chose is

known as the "Leader" burner, with a wick an inch and a half wide. It has an unusually strong draught and good combustion, giving an intense white flame. In using it, the edge of the flame is turned to the microscope, as in the resolution of difficult tests.

To obtain the desired amplification even with a $\frac{1}{15}$ in. objective, the full extension of the camera bellows is necessary, or the use of an amplifier in the microscope tube. Without pretending to be sure that my method is the best, I will still say that I have thus far got the best results by using the No. 1 ocular in the microscope, and no other amplifier. It seems to me that after correcting the objective with care so as to present the best results to the eye directly, the satisfactoriness of image which is thus produced is best kept by using both objective and eye-piece in photographing, precisely as in looking, and with the same length of tube; changing nothing but the fine adjustment to correct the focus for the position of the camera screen. Such, at least, is the conclusion I have tentatively reached.

The thing I have specially aimed at has been to correct the objective by the collar with the utmost care to procure clear definition of the broken edges of the valves, and to reduce the diffraction as much as possible, also, by this means and by the manipulation of the light. After patient experimenting to secure this, I place the tube in a horizontal position and attach it to the camera with as little change of conditions as may be. I use an achromatic condenser which is a slight modification of a Kellner eye-piece, with violet-blue modifier and a variety of movable diaphragms and stops at the back. These were not specially provided for photography; but being such as I am in the habit of using in actual investigations, I have, on the principle before stated, continued their use with the camera.

With the exception of one or two negatives, all my photographs have been made with light strictly central; for I have sought to secure dioptric images and to avoid diffraction ones as far as possible.

So much as to methods. The facts in structure which the photographs are evidence upon are these:

1st. The character of the costæ in *Navicula major*. (*Pinnularia*, W. Sm.)

2d. The existence of films of siliceous above and below the large hexagonal cells in *Triceratium favus*, *Coscinodiscus oculus-iridis*, and *Heliopelta*.

3d. That the "dots" of diatoms are areolæ as shown by the fractured edges of a considerable series of examples, ranging from the coarsest to *Pleurosigma angulatum*, inclusive.

I do not mean to repeat here the discussion of the subject, but only to present the photographs as illustration of what I have said in the series of articles which has been mentioned. I will only add that it has been a cardinal rule with me to leave the photograph untouched as it comes from the chemical processes involved. Any "stopping out," stippling, or retouching in any of the forms known to practical photographers, must, in my opinion, greatly diminish the value of a photograph for scientific purposes by introducing more or less of personal interpretation.

It will be seen from the description of the plates that the exposure was not always strictly in proportion to the amplification. The greater the difference in refractive index, the stronger is the apparent outline of the object and the quicker is a negative taken. The dry mounts and those in Professor Smith's very dense medium were therefore taken more quickly than the balsam mounts.

But within moderate limits the amplification was varied, whilst the time of exposure and the medium remained the same. The plates so taken were not of the same density, but the only important resulting difference was that the denser plates printed more slowly. Again, it is difficult, if not impossible, to manipulate the light so as to make it entirely uniform on different evenings. The lamp may be a little differently trimmed, or the state of the atmosphere may affect it, or the plates themselves may not be quite alike. There will therefore be, at last, room for the exercise of judgment based on experience as to the exposure to be given, and one must expect to spoil a plate occasionally.

The shorter series of "Broken Shells," of which I have prepared transparencies, is as follows:

No. 5. *Nitzschia scalaris* and *Navicula sculpta*, Ehr. $\times 650$, exposure $6\frac{1}{2}$ min. Fracture through rows of dots in both shells. From Müller's balsam mount of Sodertelge mud (Sweden).

No. 6. *Epithemia turgida*, Kutz. $\times 760$, exposure $6\frac{1}{2}$ min. Showing sub-rectangular reticulation at broken edge. From same slide as the last.

No. 7. *Navicula lyra*, Ehr. $\times 700$, exposure $6\frac{1}{2}$ min. Showing fracture through radial row of dots between costæ, and through the dots on the broken edge. From Möller's balsam mount of Samoa sea-mud.

No. 10. *Navicula maculata*, Edwards. $\times 1120$, exposure $6\frac{1}{2}$ min. Similar fracture to the last. From H. L. Smith's mount of Mobile bay diatoms in dense medium; refractive index, 2.4.

No. 11. *Odontodiscus subtilis*, Ehr. $\times 1375$, exposure 10 min. Showing wedge-shaped segment broken out, the fracture being through the rows of dots. From Möller's balsam mount of Wedel sea-mud.

No. 14. *Coscinodiscus obscurus*, A. Schmidt. $\times 950$, exposure $6\frac{1}{2}$ min. Showing close hexagonal and loose circular areolation in same shell. From Möller's balsam mount of Nottingham earth.

No. 17. Same as No. 5 except amplification; $\times 960$, exposure $6\frac{1}{2}$ min.

No. 20. *Odontodiscus subtilis*, Ehr. $\times 1320$, exposure $6\frac{1}{2}$ min. Showing a radial crack through a row of dots from center to circumference. From same slide as No. 11.

No. 21. *Coscinodiscus oculus-iridis*, Ehr. $\times 1600$, exposure 9 min. Showing dotted film covering the large hexagonal areolæ and projecting beyond the walls of these. From Möller's balsam mount of Nottingham earth.

No. 22. Same as last, but with stop for oblique light in the condenser. Exposed 12 min., and plate afterwards intensified with mercuric bichloride.

No. 23. Another specimen of same, showing group of large central cells with dotted film. $\times 1600$, exposure 14 min.

No. 24. *Navicula granulata*, Breb. $\times 950$, exposure 9 min. Showing several fractures through the dots. From H. L. Smith's type slide in balsam.

No. 25. *Odontodiscus subtilis*, Ehr. $\times 1100$, exposure 14 min. Showing crack through dots and nearly parallel to the rim. From same slide as Nos. 11 and 20.

No. 26. *Triceratium favus*, Ehr. $\times 1333$, exposure 10 min. A fragment showing film with radiating dots over the large hexagons. In dense medium (2.4.) Same slide as No. 10.

No. 27. *Actinoptychus heliopelta*, Grunow. $\times 940$, exposure 7 min. Showing finely dotted film extending far beyond large hexagons, and the fracture through the fine dots. From Peticolas' balsam mount of Calvert Co., Md., earth.

No. 28. *Coscinodiscus oculus-iridis*, Ehr. $\times 900$, exposure 7 min. A fragment of the inner film, showing the "eye-spots." From same slide as the last.

No. 29. Same as 28 with slightly different focus.

No. 31. *Pinnularia major*, W. Sm. $\times 870$, exposure $6\frac{1}{2}$ min. Showing costæ standing out like the teeth of a comb, the thin connecting film being mostly removed. From H. L. Smith's type slide of *Nav. rhomboides* in dense medium (2.4.)

No. 35. *Navicula granulata*, Breb. $\times 1000$, exposure $5\frac{1}{2}$ min. Showing fractured margin, the break being through the dots. From H. L. Smith's dry mounted type slide.

No. 38. *Navicula serians*, Kutz. $\times 1130$, exposure 10 min. Showing fracture through the dots. From Möller's balsam mount of Monmouth, Me., earth.

No. 39. *Pleurosigma angulatum*, W. Sm. $\times 1250$, exposure 13 min. Showing marginal fracture through the dots. From Peticolas' balsam mount of Calvert Co., Md., earth.

No. 40. *Triceratium favus*, Ehr. Same as No. 26, except amplification $\times 1800$, exposure 12 min.

No. 41. *Mastogloia angulata*, Grunow. $\times 1015$, exposure 10 min. Showing segment broken out with fracture through the dots and along the median line. From Peticolas' balsam mount of diatoms from Long Island Sound.

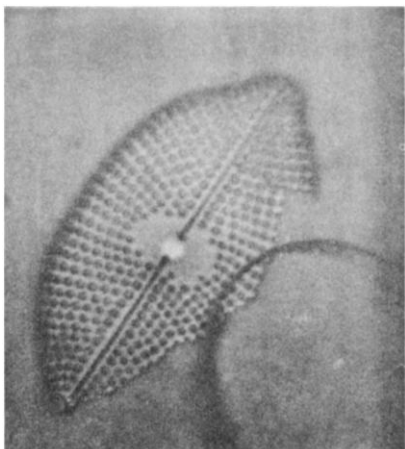
No. 44. Same species. $\times 1040$, exposure 6 min. Septum separate from valves. From Peticolas' dry mount of diatoms from Long Island Sound.

No. 47. *Coscinodiscus subtilis*, Ehr. var. *Molaris* (?), C., $\times 1130$, exposure 10 min. Showing crack through the dots. From Peticolas' balsam mount of Richmond, Va., earth.

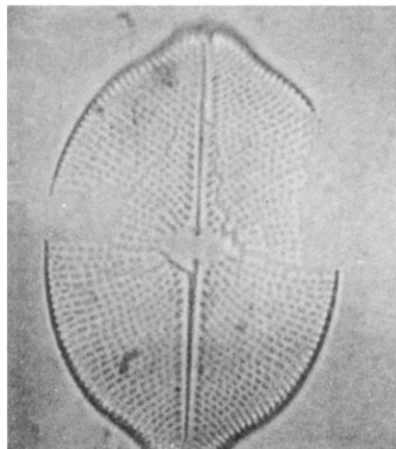
No. 50. *Pleurosigma angulatum*, W. Sm. $\times 1350$, exposure 10 min.,

and plate afterward intensified with mercuric bichloride. Showing marginal fracture through dots, and same on the surface where the shell has been crushed. From Peticolas' dry mount of Nottingham, Md., earth.

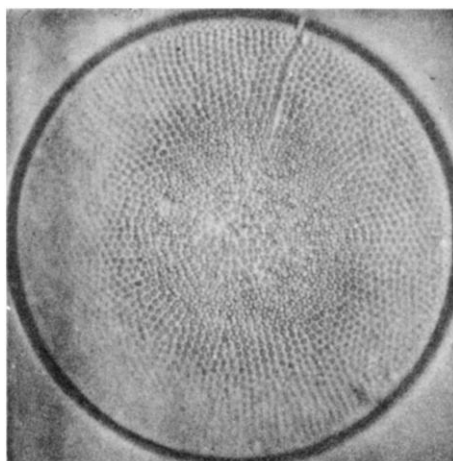
No. 51. *Mastogloia augulata*, Grunow. $\times 1314$, exposure 8 min., and plate afterward intensified. One side broken away, showing fracture through dots. From Peticolas' dry mount of Long Island Sound diatoms.



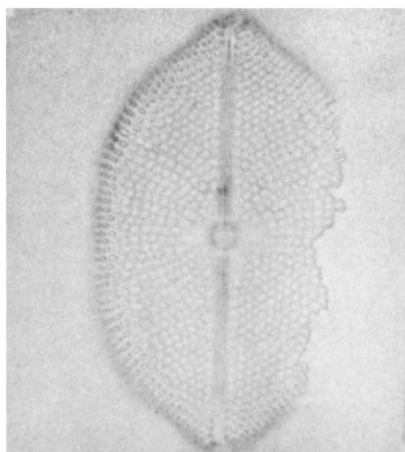
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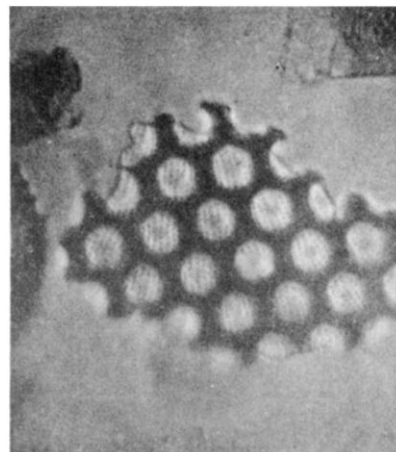
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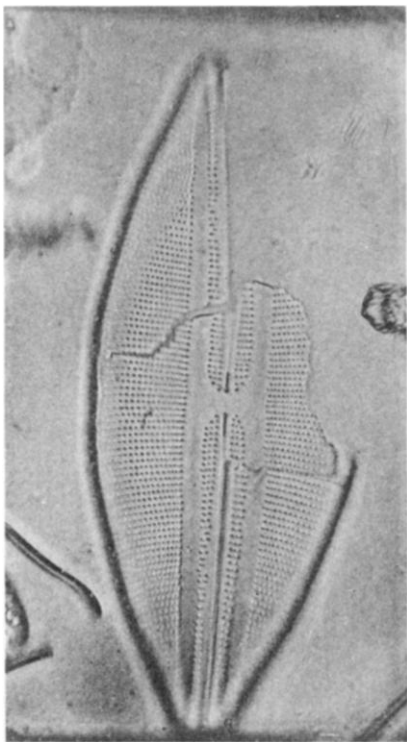
12 and 20.



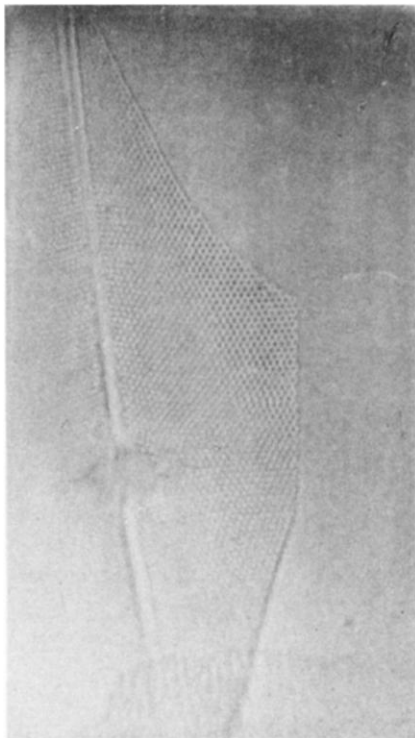
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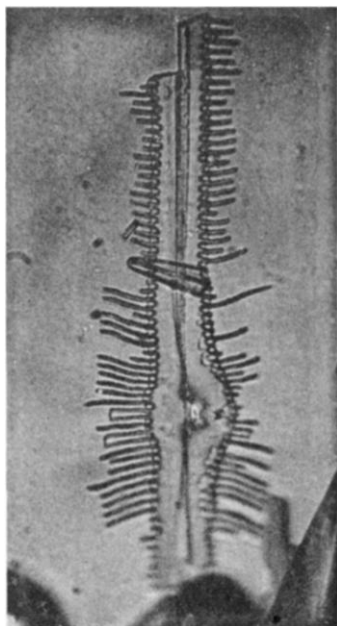
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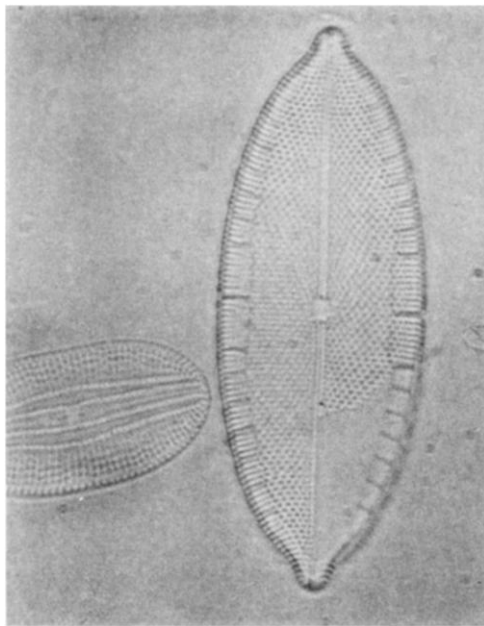
7.



39.



31.



41.